What is a Synchronous Motor ?

A synchronous electric motor is an AC motor distinguished by a rotor spinning with coils passing magnets at the same rate as the alternating current and resulting magnetic field which drives it. Another way of saying this is that it has zero slip under usual operating conditions. Contrast this with an induction motor, which must slip in order to produce torque. They operate synchronously with line frequency.

There are two major types of synchronous motors: non-excited and direct-current excited. Non-excited motors are manufactured in reluctance and hysteresis designs, these motors employ a self-starting circuit and require no external excitation supply.

Reluctance designs have ratings that range from sub-fractional to about 30 hp. Sub-fractional horsepower motors have low torque, and are generally used for instrumentation applications. Moderate torque, integral horsepower motors use squirrel-cage construction with toothed rotors. Hysteresis motors are manufactured in sub-fractional horsepower ratings, primarily as servomotors and timing motors. More expensive than the reluctance type, hysteresis motors are used where precise constant speed is required. DC-excited motors — Made in sizes larger than 1 hp, these motors require direct current supplied through slip rings for excitation. The direct current can be supplied from a separate source or from a dc generator directly connected to the motor shaft. Slip rings and brushes are used to conduct current to the rotor. The rotor poles connect to each other and move at the same speed - hence the name synchronous motor.

The speed of a synchronous motor is determined by the following formula:
ns = 120 * f / p where,
ns = synchronous speed (rpm)
f = frequency of AC supply (Hz)
p = number of magnetic poles

A synchronous motor is composed of the following parts:

• The stator is the outer shell of the motor, which carries the armature winding. This winding is spatially distributed for poly-phase AC current. This armature creates a rotating magnetic field inside the motor.

• The rotor is the rotating portion of the motor. it carries field winding, which may be supplied by a DC source. On excitation, this field winding behaves as a permanent magnet.

• The slip rings in the rotor, to supply the DC to the field winding, in the case of DC excited types.

The armature winding, when excited by a poly-phase (usually 3-phase) winding, creates a rotating magnetic field inside the motor. The field winding, which acts as a permanent magnet, simply locks in with the rotating magnetic field and rotates along with it. During operation, as the field locks in with the rotating magnetic field, the motor is said to be in synchronization.

Once the motor is in operation, the speed of the motor is dependent only on the supply frequency. When the motor load is increased beyond the break down load, the motor falls out of synchronization i.e., the applied load is large enough to pull out the field winding from following the rotating magnetic field. The motor immediately stalls after it falls out of synchronization.

Uses

• Synchronous motors find applications in all industrial applications where constant speed is necessary.

• Improving the power factor as Synchronous condensers.

• Low power applications include positioning machines, where high precision is required, and robot actuators.

Advantages

Synchronous motors have the following advantages over non-synchronous motors:

• Speed is independent of the load, provided an adequate field current is applied.

• Accurate control in speed and position using open loop controls, eg. stepper motors.

• Their power factor can be adjusted to unity by using a proper field current relative to the load. Also, a "capacitive" power factor, (current phase leads voltage phase), can be obtained by increasing this current slightly, which can help achieve a better power factor correction for the whole installation.

• Their construction allows for increased electrical efficiency when a low speed is required (as in ball mills and similar apparatus).

• They run either at the synchronous speed else no speed is there.

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